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Factsheet

SOILLESS MIXES FOR POTTED PLANTS

(Replaces Factsheet "Soilless Mixes", April 1983)

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Soilless mixes have replaced soil-based mixes in the past decade. Whether the mix is used for plant growing, propagation, container growing or bench crops, there has been a gradual reduction in the use of actual soil and an increase in the use of artificial ingredients. Soilless mixes are available already prepared in bags or bales, in bulk, or as separate ingredients that can be blended together. This Factsheet describes the factors involved in preparing a growing mix having physical and chemical properties suitable for optimal growth.

WHY SOILLESS MIXES?

Soilless mixes offer several advantages over a conventional soil mix:

(1) Uniformity and consistency from one batch to the next.

(2) Most are considered to be essentially disease and insect-free, thereby reducing the need for costly pasteurization.

(3) There is less likelihood of contamination from herbicide residues, as may occur with mixes containing field soil.

(4) The ingredients of a soilless mix are readily available and most are lightweight compared to soil.

(5) Soilless mixes have greater porespace and higher water holding capacity than mixes containing soil.

FUNCTIONS OF A MIX

A mix should perform four basic functions for plants:

(1) Provide an anchor system for the plant roots.

(2) Store water for plant-root absorption.

(3) Provide a buffer for nutrients that can be absorbed by the roots.

(4) Provide oxygen (air space) for root respiration.

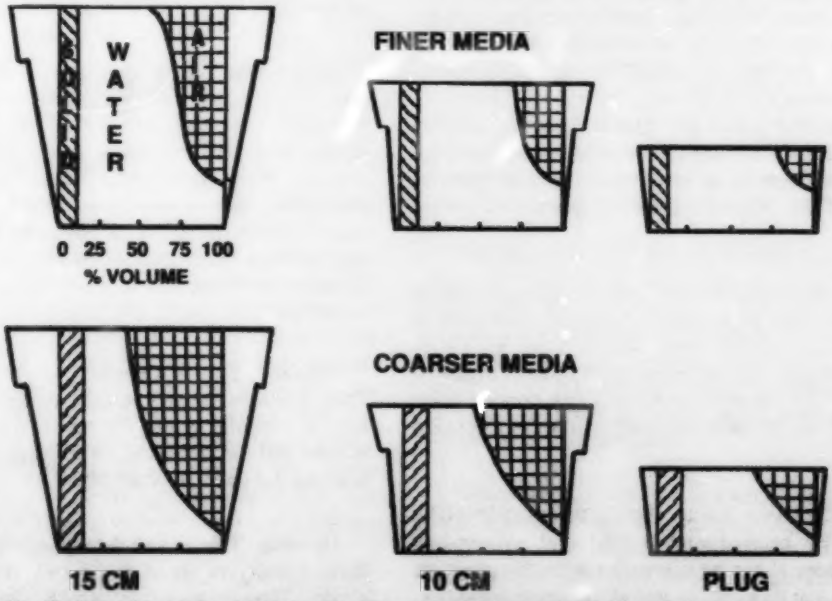

Figure 1. Volumetric distribution of particles (solid), water (liquid) and air space for 3 container sizes and 2 types of media after saturation followed by free drainage.

COMMON INGREDIENTS

Sphagnum peat moss This is one of the most widely used materials due to its physical characteristics and price. Sphagnum moss is a primitive plant which grows in bogs. While the upper part of the plant continues to grow, the bottom part dies, decomposing into peat. The moss leaves consist of living cells which may or may not contain chlorophyll, as well as dead "sphagnum" cells which contain water and air. The dead sphagnum cells are unique in that they can absorb and conduct water. These cells have lignified walls that prevent their collapse when drying out. Water in these cells is absorbed by capillary action. Because the leaf and stem cells are surface active and are generally negatively charged, they can adsorb nutrients (i.e. positive ions) in a similar way to clay particles. Nutrients can also be absorbed in the sphagnum cells as dissolved ions in water.

A sphagnum peat bog has a top, middle and bottom. Because of the way sphagnum grows, the older mosses will be at the bottom, and are the most decomposed. These are darkest in colour and finest in particle size. The top layers are more yellowish, and coarser in structure. The coarser the peat, the lower the bulk density, the greater the air space, and the smaller the water-holding capacity (by volume).

The method of peat moss harvesting plays an important role in the particle size distribution. There are two ways in which peat is harvested - the vacuum method and the block procedure. The vacuum harvesting method involves loosening the surface, air drying and vacuuming the top surface of the bog. Block harvesting involves digging the peat in chunks and letting them overwinter to dry. The following spring the chunks are loosened and packaged. Block-harvested peat is coarser than vacuum harvested.

Cation exchange capacity (CEC), gives an indication of how many cations can be adsorbed per unit weight and how their supply to plants will be regulated. With its high CEC, peat moss is well suited as a nutrient reserve and buffering agent. Pure peat moss, however, contains very few nutrients as determined by the electrical conductivity of the saturated medium extraction method (EC< 0.5 mS/cm).

Due to its naturally low pH (3.5-4.5), peat moss is considered to be free of active pathogenic diseases, although dormant pathogenic spores or weed seeds may be present. Some people claim that peat moss suppresses fungal diseases.

The low cost on a volume basis makes peat moss one of the more desirable mix ingredients. Normally, commercial and grower-made mixes today consist of 50-100% sphagnum peat moss. The sphagnum peat mosses available today in Ontario are generally sold in a compressed form and will expand by 40-60% depending on compression level.

Vermiculite This is a mica-like material (platelike structure) which has been expanded under high temperature (900°C). This material can be compared with clay particles except that it has lost its swelling and shrinkage capabilities. It has a high cation exchange capacity (CEC), similar to peat moss on a weight basis, and contains considerable potassium and magnesium ions. It improves the air porosity, provides structure to the medium (less shrinkage), and makes rewetting of a mix easier. Water can also be absorbed internally between the platelets. Acidity is near neutral and bulk density is 80-100 kg/m3. Three grades are normally available - coarse, fine and regular. It is mined in Washington (USA) and South Africa.

Perlite This is an aluminum-silicate of volcanic origin which has been heated to about 1000°C. It is similar to popcorn as it consists of a number of closed, air-filled cells. Water is absorbed primarily on the outer surface and to a lesser degree within the particle. This inert material is primarily added to the mix to improve aeration and drainage as well as structural stability of the mix. The pH is about 7.0 while the CEC is negligible. Bulk density is similar to that of vermiculite or peat moss, about 100 kg/m^3.

Rockwool This product is manufactured from 'spinning' molten rock. There are 2 forms available, namely, the bonded product and the granulated material. The base material is sterile and does not contain any CEC or an appreciable level of soluble salts. The bonded product is cut into slabs 15 or 20 cm wide, 7.5-10 cm thick and 90-200 cm long, and is used primarily for the production of greenhouse vegetables (tomatoes, cucumbers and peppers) or cut flowers (roses, gerbera). It can be purchased with or without a plastic sleeve. Slabs contain a binder for stability and a wetting agent to facilitate water absorption and distribution. The granulated material comes in 3 sizes (fine, medium and coarse) and does not contain any binder and/or wetting agent. Granulated rockwool is added to a mix to increase porespace and water holding capacity and for easier rewetting if the medium is allowed to dry out.

Rockwool can also be manufactured from steel slag. This material, often referred to as 'mineral wool', generally has a relatively high pH (7-8) and higher levels of micronutrients, compared with rockwool.

Polystyrene chips This is a waste product created from polystyrene bead boards. The material is inert, with negligible CEC and near neutral pH. Its role in a media is similar to perlite except that there is no surface absorption of water. Bulk density is 25 kg/m^3, and it cannot be pasteurized due to shrinkage. It has a tendency to float to the surface of the pot and can be a nuisance with recirculating subirrigation systems. Soil-mix uniformity can be of concern because of its tendency to separate from the rest of the mixture.

Turface This is a baked clay with neutral reaction (pH 7.0). Because the bulk density is 750 kg/m^3 and the CEC is high for regular grade, the material is used to increase the weight and the buffering capabilities of the mix. The CEC is about the same as vermiculite.

Haydite This is a shale expanded by heating to 1200°C. Bulk density is about 800 kg/m^3 depending on size and grade. It has a high pH (8.5-9.5) and can be obtained in several grades according to particle size. The neutralizing

capacity of this material has to be considered when used in appreciable quantities.

Gro-Bark Composted barks may suppress toxic substances and plant pathogens. Hardwood barks are generally composted for 3 months, while softwood barks take about 1 1/2 months to compost. Nitrogen is generally added at 1 kg or 0.5 kg/m^3 for hardwood and softwood bark, respectively, before composting. Gro-Bark, a commercially available product, is a blend of aged pine bark and sawdust that has been naturally composted for 10 to 40 years. It ranges in pH from 4.5 to 6.5 and is low in salts. Available in bulk only, it is often used as bedding in walkways, as an amendment for containerized nursery material, or as a substitute for peat moss.

Grow-Rich A composted material which is produced from papermill sludge and other organic materials (animal manures, sawdust and corncobs). The bulk density is about 400 kg/m^3, while typical particle size ranges from 3-6 mm. The pH is between 5.5 and 6.5, and soluble salts are near 1.5-2.0 mS/cm using the saturated medium extraction method. As a consequence, the final potting mix should not contain more than 25% of this material.

Worm Castings This is a by-product of worm raising. It is high in organic content and stable in structure. The pH is 6.0-7.5 while soluble salts are between 1.0-1.5 mS/cm. Bulk density is about 200 kg/m^3. It should also be used sparingly in a mix (less than 25% of the volume) to provide structural stability and more porespace to the media. It is somewhat hydrophobic in nature. Its price is high.

Sand Although technically a type of soil, sand is quite often incorporated into soilless mixes to provide weight. It is about 15 times heavier than the other major components (peat, perlite, vermiculite). Drawbacks with sand include its grinding action on the other ingredients if mixed too long, causing a reduction in air space, or it may contain plant pathogens, therefore requiring pasteurization and its possible effect on medium pH over time. However, sand (similar to soil) improves wettability of the mix. Depending on its source, sand often has a high pH (about 8.5), indicating the presence of free calcium carbonates. When used, its neutralizing capacity should be considered.

PHYSICAL CHARACTERISTICS OF A MIX

A soilless (or soil) mix has three major portions - air, solids and water. The air space is needed to provide oxygen for root respiration and to allow nitrification and some microbial activity. The air space in a mix complements the water portion, since air replaces the water absorbed by the plant roots. The air/water ratio in a mix is determined by the particle size of the solids. After watering a coarse mix, air will enter the mix quicker than it will in finer mixes but may not be distributed uniformly. Therefore, a coarse mix has relatively more air and less water-filled pore space than a fine one. A lack of air space can be a problem when using a fine-textured mix during the lower light periods of the year. Another factor which affects the ratio of water and air is the height of the pot (Figure 1).

After watering, several of the soilless mixes will have 75% of the total space filled by water, with the remainder taken up by solids (5-10%) and air (15-20%). In a soil mix, solids compose 50% of the space, with the balance divided between air and water. This basic difference between a soil and soilless mix therefore necessitates a change in crop management. The bulk density of most soilless mixes is about 100-200 kg/m^3. Shrinkage of the mix is of some concern due to the changing physical properties, but also due to the volume of the medium required for a given pot size. Peat moss and rockwool both may shrink. The addition of structural components such as perlite or vermiculite, or compressing the mix when filling the pots, helps to alleviate medium shrinkage.

PREPARING A SOILLESS MIX

There are several considerations: (1) water holding capacity, (2) air porosity, (3) nutrient availability, (4) buffering capacity, (5) weight, (6) price.

An example of a standard mix that meets these requirements is given in Table 1.

Table 1. Example of a Soilless Mix with Amendments

Ingredients	Percent (by volume)
Sphagnum peat moss	50-60%
Vermiculite, perlite, polystyrene, bark, granulated rockwool	20-40%
Turface, Haydite, sand	10-20%
Amendments	**Rate per cubic metre of mix**
Limestone (fine grade, dolomitic)	3.5 kg
Superphosphate (0-20-0, fine grade)	1.5 kg
Potassium nitrate (12-0-44) or ammonium nitrate (34-0-0)	1.0/0.4 kg
Trace elements (Nutritrace)	250-500 g
Wetting agent	100 mL

The major component is sphagnum peat moss due to its excellent properties. The quality of the peat moss is important as it is the principal ingredient. A coarse peat provides more natural air space and could be used at a higher percentage in the mix. For aeration purposes and to give structure to the mix (less shrinkage), one or a combination of the following ingredients should be used: vermiculite, perlite, granulated rockwool or polystyrene chips. Vermiculite and rockwool are excellent materials, as they increase water holding capacity as well as the rewetting characteristics. The third ingredient (Turface, Haydite) is added for weight, buffering capacity and/or porespace.

The limestone (3.5 kg/m^3 of mix) is added to bring the pH of the mixture to an acceptable level based on the mix containing 50% peat moss. The amount of limestone indicated does not take into account any neutralizing effects from the other ingredients (e.g. Haydite, sand) or the acidifying effect of some fertilizers (ammonium nitrate). It may take one week after mix preparation and initial wetting before the pH is stabilized.

When calcitic limestone is used, apply magnesium in the form of Epsom salts (0.5 kg/m^3). Superphosphate is added for phosphorus, sulphur and calcium. If nitrogen and/or potassium are also to be added, use potassium nitrate (12-0-44) at 0.5 to 1.0 kg/m^3, or ammonium nitrate (34-0-0) at 0.3-0.5 kg/m^3. The nitrogen addition would amount to about

0.25-0.50g N per 15 cm pot. In some instances, calcium nitrate may be used as the nitrogen source at 0.5 kg/m^3. The trace elements Fe, Cu, B, Zn and Mn can be added using Nutritrace. As a wetting agent, a non-ionic reagent such as Aqua-grow or Agral 90 is suitable. The wetting agent should be dissolved in warm water and sprayed over the mix for uniform distribution. Sometimes a combination of trace elements and wetting agent is available in granular form. For convenience purposes, many growers have their amendments premixed by their fertilizer supplier. Most ingredients can be mixed when dry. Screw-turn and tumbler-type mechanical mixers can be used, but pulverization of components should be prevented by minimizing mixing time. Water can be added when the ingredients are being mixed.

CHEMICAL CHARACTERISTICS OF MIXES

After a mix is prepared, always check the soluble salts (EC) and pH. The EC gives an indication of the nutrient status by measuring the conductivity of the solution, while the pH determines the nutrient availability. The optimal pH for organic mixes is around 5.5 (±0.5). This contrasts with the recommendation of 6.5 for soil mixes. In the peat-like mixes, a high pH (over 6.5) can cause manganese, boron, copper, zinc and phosphorus deficiencies, while a pH of 5.0 to 5.5 can cause molybdenum deficiency (especially in poinsettias). Addition of ammonium nitrate at 400 g/m^3 may reduce the pH by about 0.5 unit.

READY-MADE MIXES

Most commercially-prepared mixes have been tested and will perform well when managed properly. When comparing prices, the cost of materials, mixing equipment, storage space, as well as labour cost for making the mixes are important and should also be considered. Smaller operations often use ready-made mixes. Some manufacturers will blend and deliver mixes to growers specifications. The ready-made mixes usually follow the above outline of ingredients, although the third major ingredient (Turface or sand) is usually omitted. Most ready-made mixes have a pH of 5.5-6.0 and an EC of 1.2-1.8 mS/cm using the saturated paste extraction method, while water holding capacity is about 70% on a volume basis after a 15 cm diameter pot is totally saturated and allowed to drain.

COMPOSTS

Some growers may choose to use composted material as part of their soilless mix. Composts may contain antagonistic fungi and bacteria to suppress plant diseases as well as other beneficial microorganisms (such as nitrifying bacteria).

Composts made from assortments of organic by-products are available in bulk from various suppliers at relatively low costs. These may be used successfully as amendments, but it is advisable to check pH and soluble salts before use.

COMMON PROBLEMS

1. Mixing the ingredients of a soilless mix for too long a period grinds the particles together, breaking them down and thereby destroying medium structure. A general guideline is 3 to 5 minutes at 12-14 rpm.

2. Rewetting a soilless mix after it has dried out is difficult, but not impossible. It can be accomplished by several light waterings or mist applications. A wetting agent can also be added to the water at approximately 1 mL per L of warm water. Normally, the wetting agent is added when mixing the ingredients. Addition of granulated rockwool or vermiculite improves the rate of rewetting after severe drying out. Excessive levels of wetting agent incorporated into the medium, i.e. 2-3 times the recommended rate, can result in the development of only a few long stringy roots or a failure of the roots to penetrate the medium. This may cause overall stunting of sensitive species, including impatiens, begonia and cucumber.

3. Algal growth on the surface may restrict seedling emergence, reduce water penetration and/or serve as a breeding site for fungus gnats. Some fungicides may reduce algal growth; also, as the plants grow, reduced light level on the surface will restrict development of algae. Agribrom is added to the irrigation water at 5-10 ppm of residual bromine to control/prevent algal growth. Algae-free irrigation water reduces this problem as well.

4. Optimal nutrient levels are usually higher than in a soil mix. Therefore, it is important to keep the crop well fertilized. Soluble-salts readings can safely be about twice as high as those in a soil mix.

5. Magnesium deficiency symptoms show up quickly on crops like tomatoes and chrysanthemums. This is because the conventional water-soluble "complete" fertilizers do not have magnesium present. Preplant incorporation or separate feedings of Epsom salts or magnesium nitrate will help control this situation.

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